CASE REPORT

Electroencephalography of the Fetus

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A STUDY has been undertaken at Jefferson Medical College Hospital to investigate intrauterine fetal physiology, including examination of the functional development of the fetus. This report presents the records of brain activity from two fetuses.

The specimens were obtained from abdominal section. The older fetus was removed together with the uterus (abdominal hysterectomy). The other fetus was obtained from an early tubal pregnancy. Both specimens were placed in towels soaked with warm (37° C.) normal salt solution and immediately removed to the laboratory. All recordings were made with needle electrodes and recorded on a standard Grass eight lead electroencephalograph. In neither instance was an attempt made to preserve life in the fetus.

Electrodes were placed in areas corresponding to the frontal and occipital lobes. Only bipolar recordings were made. The readings were made from the right frontal to right occipital area; from the left frontal to left occipital area. Recordings were also made between the frontal areas. A similar recording was made with the occipital leads. At first the electrodes were placed into the cortex for a depth of approximately 3 mm. and readings were taken at this depth. After this cortical area ceased to record, the electrodes were inserted into a deeper position (1 cm.), and the procedure was repeated.

The fetuses were examined carefully to determine the age of each. At the present time, it suffices to state the ages without detailed embryologic explanation. The older fetus was 77 days old (CR length = 62 mm.; CH length = 95 mm.); the younger fetus was 43 to 45 days old (CR length = 16 mm.).

REPORT OF CASES

Case 1.—(77 days; intrauterine pregnancy)

In addition to the procedure previously described, silver electrodes were placed on the surface of the uterus, on the unopened amniotic sac, and on the fetal skull. These readings showed low voltage slow wave activity. This activity was constant and its rhythm was at 2 cycles per second. No fast activity was noted.

When the electrodes were inserted into the brain substance for a depth of approximately 3 mm., high voltage slow wave activity with some superimposed low voltage fast waves appeared. This activity lasted approximately 14 minutes from onset of recording (59 minutes after removal of uterus).

When the above-mentioned activity ceased, the electrodes were placed at a depth of 1 cm. and again the high voltage slow wave activity with superimposed fast activity was

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obtained. As time progressed the voltage decreased and the slow wave activity began to disappear. During this change, paroxysms of slow wave activity with fast waves superimposed appeared. All electrical activity of the brain had completely disappeared in 91 minutes from the time of ligation of the uterine arteries. Metrazol was applied topically and intracortically at this time without any revival of cortical activity. No electrocardiographic activity was noted at any time.

Case 2.–(43 to 45 days; ectopic pregnancy)

The pattern of activity in this younger fetus resembled that described above. No attempt was made to obtain readings from surface structures and the needle electrodes were placed into the substance of the brain. In this case paroxysmal rebound activity was noted from the superficial cortex. The activity from the superficial cortex completely disappeared in 62 minutes from onset of recording (72 minutes after removal of the Fallopian tube). In general, the type of waves obtained in this fetus were the same as those of the other specimen.

In addition, bursts of fast wave activity (16/sec.) from the superficial cortex and deeper structures of the brainstem were seen on two occasions. These waves resembled sleep spindles as observed in the adult electroencephalogram.

The activity from the deeper structures lasted 88 minutes. Electrocardiographic activity was noted for 78 minutes and showed progressive slowing.

DISCUSSION

The electrical activity of the fetal brain has been a matter of conjecture for years. Jasper and his associates[2] believed that the cerebral electric potentials were absent throughout most of fetal life. They found tardy prenatal development of this activity in the guinea pig. More recently Okamoto and Kirikae[3,4] studied electro-

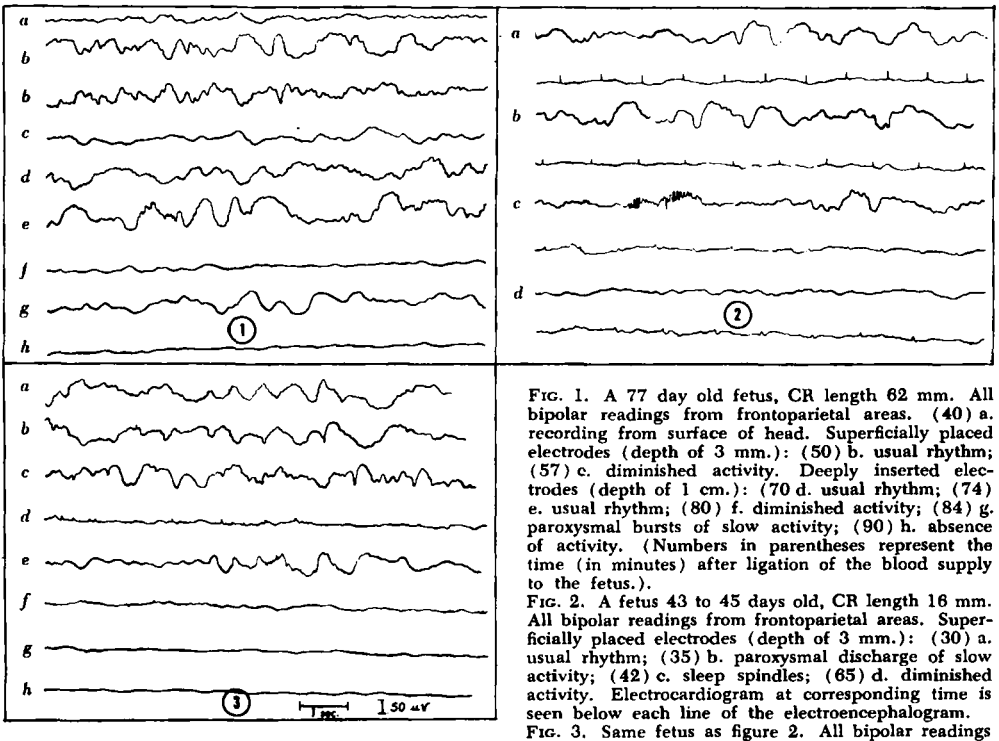

FIG. 1. A 77 day old fetus, CR length 62 mm. All bipolar readings from frontoparietal areas. (40) a. recording from surface of head. Superficially placed electrodes (depth of 3 mm.): (50) b. usual rhythm; (57) c. diminished activity. Deeply inserted electrodes (depth of 1 cm.): (70 d. usual rhythm; (74) e. usual rhythm; (80) f. diminished activity; (84) g. paroxysmal bursts of slow activity; (90) h. absence of activity. (Numbers in parentheses represent the time (in minutes) after ligation of the blood supply to the fetus.).

FIG. 2. A fetus 43 to 45 days old, CR length 16 mm. All bipolar readings from frontoparietal areas. Superficially placed electrodes (depth of 3 mm.): (30) a. usual rhythm; (35) b. paroxysmal discharge of slow activity; (42) c. sleep spindles; (65) d. diminished activity. Electrocardiogram at corresponding time is seen below each line of the electroencephalogram.

FIG. 3. Same fetus as figure 2. All bipolar readings from frontoparietal areas. Deeply inserted electrodes (depth of 1 cm.): (72) a. usual activity; (72) b. usual activity; (74) c. paroxysmal discharge of slow activity; (74) d. marked slowing of EKG with irregularity of rhythm; (80) e. diminished activity with occasional fast wave discharge; (77) f. very occasional EKG seen; (88) g. absence of activity; (78) h. absence of EKG.

encephalograms of human fetuses obtained from abdominal or vaginal termination of pregnancies. Their specimens include 16 fetuses (three to seven months), two premature infants (eight and nine months), and several full term infants. The youngest specimen they reported was three months, 8.5 cm. The recordings were chiefly monopolar. Their results showed very irregular waves of 10 to 90 microvolts with the superimposition of regular fast waves of 5 microvolts. The duration of the recordings was not mentioned, nor was the lapse of time after delivery noted. Thus the activity described may represent, for the most part, paroxysmal discharges as seen in the specimens reported here.

In the older fetus, the absence of paroxysmal activity from the superficial cortex may have been the result of delay in the placing of the electrodes into the cortex and the resultant short period of recording from this area. The types of waves noted from the superficial cortex and deep structures in both fetuses were similar and resembled the activity reported by Okamoto and Kirikae[3,4] in older fetuses. We prefer to regard this type of activity as a usual finding in the fetal brain. Although our specimens were very young, Okamoto and Kirikae[3,4] were able to demonstrate similar findings in infants born prematurely at the eighth and ninth months. The brain activity of a full term infant is quite different. Phylogenetically the same type high voltage slow waves with superimposed fast activity has been observed in mature birds,[5] in the mature frog,[6] and in the mature rabbit and mature marmot.[7]

Paroxysmal activity has not been reported previously. We believe that it may be the result of terminal electrical discharge of dying cells. The disappearance of this activity was first observed in the frontal areas. The activity disappears from the entire superficial cortex prior to disappearance of deep activity. Weinberger and his associates[8] were able to demonstrate experimentally in cats that the motor and visual cortices sustained the earliest and most profound damage following complete arrest of the circulation to the brain, while the olfactory, orbital, and temporal regions of the cortex were more resistant. This study was based on the histologic appearance of the extirpated brain. Our findings in human fetuses agree in part with their work on the brain of the cat.

Okamoto and Kirikae speculated that the origin of the brain waves which they obtained was from the brainstem, and we concur in this concept. However, fast spindles from the deep electrodes may be an indication of either early activity or even sleep in the fetus (which may represent discharge from the reticular substance). The same activity was observed in the superficial cortex and may represent transmission of activity from the midbrain by way of the reticular system to the cortex. In addition, we believe that the individual cells possess inherent electrical charge and that the disappearance of activity is a representation of dying cells in the cortical layers.

We were not able to obtain any response from the "electrically dead" fetal brain wtih Metrazol. Okamoto and Kirikae[3,4] demonstrated responses to both sedatives and stimulants; however, it may well be that this portion of their experiment was undertaken soon after the fetus was delivered, while in our case Metrazol was administered after all activity had ceased.

SUMMARY

1. Tracings were made from the brains of two fetuses, one 77 days old, the other 43 to 45 days old.

2. Bipolar readings were made and similar activity was obtained in both cases. The activity consisted of irregular slow waves with superimposed fast waves. A similar pattern (slow waves

with superimposed fast waves) of paroxysmal rebound activity was observed in both fetuses.

3. Cerebral activity disappeared initially from the frontal areas.

4. Deep activity persisted after superficial activity disappeared; this was correlated with the electrocardiogram.

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■ *What is the cause of pain produced by the irritation of the anterior roots of nerves?* According to Carus, the nervous loops, which he thought existed in the muscles, give an easy explanation of the facts discovered by Magendie. Unfortunately for this explanation the existence of nervous loops in muscles is now disproved. Indeed, even in the skin there is good ground to doubt the presence of many loops. Some experiments, which we have made, render it probable that the pain caused by the irritation of the anterior roots is exactly of the same nature as that of cramps, and that both the pain of cramps and the pain which we will call recurrent, to avoid circumlocutions, depend upon a peculiar kind of irritation of the sensitive nerves of muscles. The theory we will propose is also applicable to many pathological and physiological phenomena, which have puzzled for a long while both practitioners and physiologists, and which seem, indeed to be very plain and natural now that we have the key to their explanation.

C. E. Brown-Sequard in *Lectures on the Physiology and Pathology of the Central Nervous System,* published in 1860.

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